Geophytology 41(1-2): 61-73
December 2011

Distribution of lichens on fallen twigs of *Quercus leucotrichophora* and *Quercus semecarpifolia* in and around Nainital city, Uttarakhand, India

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ABSTRACT

Kholia H., Mishra G. K., Upreti D. K. & Tiwari L. 2011. Distribution of lichens on fallen twigs of *Quercus leucotrichophora* and *Quercus semecarpifolia* in and around Nainital city, Uttarakhand, India. Geophytology 41(1-2): 61-73.

Lichens growing on fallen twigs of *Quercus leucotrichophora* and *Quercus semecarpifolia* in twenty localities in and around Nainital city are enumerated. Both *Q. leucotrichophora* and *Q. semecarpifolia* exhibit occurrence of 49 species of lichens belonging to 32 genera and 12 families. Among the four diameter classes of twigs (1.0-2.0 cm, 2.1-4.0 cm, 4.1-6.0 cm, 6.1-8.0 cm), the diameter classes of 2.1-4.0 cm and 4.1-6.0 cm of both *Q. semecarpifolia* and *Q. leucotrichophora* exhibit maximum diversity of lichens represented by 32, 32 and 34, 28 species respectively. The foliose forms of lichens exhibit their dominance in all the four diameter classes of twigs of both the trees followed by crustose and fruticose forms. *Quercus leucotrichophora* trees exhibit maximum diversity of twig lichens in Ramji Hospital area with 32 species followed by D.S.B. campus and Thirty Six Sheeri with 28 and 27 species respectively. *Q. semecarpifolia* trees in Snow View area bear maximum number of twig lichens represented by 31 species followed by Tower Compound and Tiffin Top with 29 and 28 species. *Q. leucotrichophora* trees in Plains View and *Q. semecarpifolia* in Kumaun Lodge sites bear the poor growth of twig lichens represented by 6 and 8 species respectively. The pH of all the diameter classes of twigs ranges from 6 to 8. The young twigs having diameter class of 1.0-2.0, 2.1-4.0, 4.1-6.0 cm show low acidity (pH 7-8) while the acidity increases (pH 6-7) in 6.1-8.0 diameter class of twigs. The diversity of lichens decreases with increase in the diameter and acidity of the twigs.

Key-words: Epiphytic lichens, *Quercus* forest, diameter, Nainital district, Uttarakhand, India.

INTRODUCTION

Lichens are widely used as indicator organism in various regions of the world that are affected by air pollution. A large number of studies regarding use of lichens in biomonotoring environmental pollution are available. The lichens growing on twigs can be used as an early warning system to detect a response to changes in land management and nitrogen deposition (Vilsholm et al. 2009). The twig lichens of *Quercus* species from some regions of the world are available. Zeddda (2002) studied the ecological indicator features of the epiphytic lichens on *Quercus* species in Sardinia, Italy. The lichen species on *Quercus pubescens* were studied by Loppi et al. (1997) in different altitudes of Tuscany region of Italy. Wolseley and Pryor (1999) investigated the lichens that colonize on thin branches of *Q. petraea.* Larsen et al. (2007) studied epiphytic lichens and bryophytes on the oak tree trunks in London. Tore and Oznturk (2009) investigated the epiphytic lichens on *Quercus* species of Uludag (Bursa) Turky. Wolseley et al. (2006, 2008) proposed a method of monitoring environmental condition with the use of lichen communities on twigs of trees.

The *Quercus leucotrichophora* and *Q. semecarpifolia* trees are the major phorophytes of temperate region in the Himalaya. The Nainital city, situated in Kumaun Himalaya of Uttarakhand, exhibits luxuriant growth of *Q. leucotrichophora* and *Q. semecarpifolia* together with other trees. *Q. leucotrichophora* grows abundantly in lower altitudes between 1500 and 2000 m, sometimes forming pure patches or mixed with *Rhododendron* and coniferous trees (*Cedrus deodara* and *Cupressus torulosa*). *Quercus semecarpifolia* dominates in the higher altitudes between 2500 and 3000 m, sometimes forming pure patches or mixed with coniferous trees. The lichens colonize on both tree branches and twigs. The twigs when assume a diameter of 1.0-2.0 cm, the colonization of lichens begins on them. All the three growth forms of lichens start colonizing on twigs at an early stage, simultaneously some foliose and fruticose species later on increase their size and replace the pioneer ones.

The long life span of *Quercus* trees, together with their smooth to thick rough characteristic features of bark, provide excellent substrate for various species of lichens and other epiphytes to colonize. The dome shaped canopy of the oak trees also helps to retain the moisture and shade on branches and trunk for longer period for epiphytes to colonize.

Upreti and Chatterjee (1999) studied distribution of epiphytic lichens in three forest stands in Pithoragarh district of Kumaun Himalaya and recorded occurrence of 24 species of lichens on *Q. semecarpifolia* followed by *Q. dilatata* and *Q. leucotrichophora* with 15 and 14 species respectively. Kumar et al. (2011) studied diversity of lichens in five diameter classes of twigs (0-1, 1.1-2, 2.1-3, 3.1-4 and >4.1 cm) of *Q. leucotrichophora* in Banlekh forest of Champawat district, Uttarakhand. In all five diameter classes, twigs of *Q. leucotrichophora* exhibit luxuriant growth of parmelioid lichens together with members of Usneaceae and Ramalinaceae.

The studies on lichens in India mainly deal with taxonomy together with few ecological and biomonitoring studies. So far, no records of lichens growing on twigs of *Quercus* and other trees are known. Therefore, the aim of this study is to enumerate and compare the twig lichen diversity between different diameter classes of twigs in two common *Quercus* species in twenty localities of Nainital city of Kumaun Himalaya, Uttarakhand.

MATERIAL AND METHOD

More than 500 samples of the twigs of *Q. leucotrichophora* and *Q. semecarpifolia* fallen on the forest floor in twenty localities in and around the city of Nainital were collected during the year 2009-2010. The twigs were grouped into four diameter classes of 1.0-2.0 cm, 2.1-4.0 cm, 4.1-6.0 cm and 6.1-8.0 cm (Tables 1A, 1B, 2A, 2B). The specimens were identified by studying their morphology, anatomy and chemistry. The morphology of the taxa was studied under stereo-zoom binocular microscope. The details of thallus anatomy and fruiting bodies were studied by compound microscope. The colour spot test were carried out on cortex and medulla with the usual chemical reagents such as aqueous potassium hydroxide (K), Steiner's stable paraphenylenediamine (PD) and aqueous calcium hypochlorite (C). Thin layer chromatography was performed in solvent system A (Toluene: 1-4 dioxane: Acetic acid) for authentic identification of the lichen substances following Walkar and James (1980).

RESULT AND DISCUSSION

A total of 49 species belonging to 32 genera and 12 families of lichens are reported found growing on four different diameter classes of twigs of both *Q. leucotrichophora* and *Q. semecarpifolia* trees. The foliose lichens dominate all four different classes of the twigs with 26 species followed by 18 crustose, 3 squamulose, 5 fruticose and single leprose species (Plates 1-4). The members of lichen family Parmeliaceae with 8 genera and 17 species exhibit their dominance on the twigs followed by 6 genera and 11 species of Physciaceae.

Among the different diameter classes of twigs, the diameter class of 2.1-4.0 cm of both the trees bears maximum number of lichen species represented by 34 and 32 on *Q. leucotrichophora* and *Q. semecarpifolia* respectively (Tables 1A, 2A). The diameter class of

Table 1A. Lichens growing on *Quercus leucotrichophora* bark in 1-2 and 2.1-4.0 cm diameter classes.

S.N.	1-2 cm	2.1-4.0 cm
1	*Amandinea punctata* (Hoffm.) Coppins & Scheid.	*Amandinea punctata* (Hoffm.) Coppins & Scheid.
2	*Arthothelium albescens* Patw. & Makhija	*Arthothelium albescens* Patw. & Makhija
3	*Bacidia millegrana* (Taylor) Zahlbr.	*Bacidia millegrana* (Taylor) Zahlbr.
4	*Bulbothrix setschwanensis* (Zahlbr.) Hale	*Bulbothrix setschwanensis* (Zahlbr.) Hale
5	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.
6	*Caloplaca trilocularis* Zahlbr	*Candelaria concolor* (Dicks.) Stein
7	*Candelaria concolor* (Dicks.) Stein	*Diorygma heiroglyphicum* (Pers.) Staiger & Kalb
8	*Everniastrum cirrhatum* (Fr.) Hale	*Diorygma junghuhnii* (Mont. & Bosch) Kalb & al.
9	*Graphis lineola* Ach.	*Everniastrum cirrhatum* (Fr.) Hale
10	*Graphis proserpens* Vain.	*Graphis lineola* Ach.
11	*Graphis scripta* (L.) Ach.	*Graphis proserpens* Vain.
12	*Graphis subserpentina* Nyl.	*Graphis scripta* (L.) Ach.
13	*Heterodermia diademata* (Taylor) D.D. Awasthi	*Graphis subserpentina* Nyl.
14	*Heterodermia incana* (Stirt.) D.D. Awasthi	*Heterodermia diademata* (Taylor) D.D. Awasthi
15	*Lecanora achroa* Nyl.	*Heterodermia incana* (Stirt.) D.D. Awasthi
16	*Lecanora alba* Lumbsch	*Hypotrachyna flexilis* (Kurok.) Hale
17	*Myelochroa subaurulenta* (Nyl.) Elix & Hale	*Lecanora achroa* Nyl.
18	*Parmelaria thomsonii* (Stirt.) D.D. Awasthi	*Lecanora alba* Lumbsch
19	*Parmotrema austrosinense* (Zahlbr.) Hale	*Lepraria lobificans* Nyl.
20	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.	*Myelochroa subaurulenta* (Nyl.) Elix & Hale
21	*Phaeophyscia endococcina* (Körb.) Moberg	*Opegrapha* sp.
22	*Phaeophyscia hispidula* (Ach.) Moberg	*Parmelaria thomsonii* (Stirt.) D.D. Awasthi
23	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi	*Parmotrema austrosinense* (Zahlbr.) Hale
24	*Physcia dilitata* Nyl.	*Parmotrema reticulatum* (Taylor) M. Choisy
25	*Punctelia rudecta* (Ach.) Krog	*Pertusaria leucosorodes* Nyl.
26	*Pyxine berteriana* (Fée) Imshaug	*Phaeophyscia hispidula* (Ach.) Moberg
27	*Ramalina conduplicans* Vain.	*Phaeophyscia endococcina* (Körb.) Moberg
28	*Rinodina sophodes* (Ach.) A. Massal.	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi
29	*Usnea eumitrioides* Motyka	*Physcia dilitata* Nyl.
30		*Punctelia rudecta* (Ach.) Krog
31		*Pyxine berteriana* (Fée) Imshaug
32		*Ramalina conduplicans* Vain.
33		*Rinodina sophodes* (Ach.) A. Massal.
34		*Usnea eumitrioides* Motyka

Table 1B. Lichens growing on *Quercus leucotrichophora* bark in 1-2 and 2.1-4.0 cm diameter classes.

S.N.	4.1-6.0 cm	6.1-8.0 cm
1	*Amandinea punctata* (Hoffm.) Coppins & Scheid.	*Amandinea punctata* (Hoffm.) Coppins & Scheid.
2	*Arthothelium albescens* Patw. & Makhija	*Bacidia millegrana* (Taylor) Zahlbr.
3	*Bacidia millegrana* (Taylor) Zahlbr.	*Bulbothrix setschwanensis* (Zahlbr.) Hale
4	*Bulbothrix setschwanensis* (Zahlbr.) Hale	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.
5	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.	*Candelaria concolor* (Dicks.) Stein
6	*Candelaria concolor* (Dicks.) Stein in Cohn	*Graphis lineola* Ach.
7	*Everniastrum cirrhatum* (Fr.) Hale	*Graphis scripta* (L.) Ach.
8	*Graphis lineola* Ach.	*Graphis subserpentina* Nyl.
9	*Graphis proserpens* Vain.	*Heterodermia diademata* (Taylor) D.D. Awasthi
10	*Graphis scripta* (L.) Ach.	*Lecanora achroa* Nyl.
11	*Heterodermia diademata* (Taylor) D.D. Awasthi	*Lecanora alba* Lumbsch
12	*Heterodermia incana* (Stirt.) D.D. Awasthi	*Leptogium askotense* D.D.Awasthi & Akhtar
13	*Hypotrachyna flexilis* (Kurok.) Hale	*Parmotrema reticulatum* (Taylor) M. Choisy
14	*Lecanora achroa* Nyl.	*Phaeophyscia hispidula* (Ach.) Moberg
15	*Lecanora alba* Lumbsch	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi
16	*Myelochroa subaurulenta* (Nyl.) Elix & Hale	*Physcia dilitata* Nyl.
17	*Parmelaria thomsonii* (Stirt.) D.D. Awasthi	*Parmotrema reticulatum* (Taylor) M. Choisy
18	*Parmotrema austrosinense* (Zahlbr.) Hale	*Punctelia rudecta* (Ach.) Krog
19	*Parmotrema reticulatum* (Taylor) M. Choisy	*Pyxine berteriana* (Fée) Imshaug
20	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.	*Usnea eumitrioides* Motyka
21	*Phaeophyscia hispidula* (Ach.) Moberg	
22	*Phaeophyscia endococcina* (Körb.) Moberg	
23	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi	
24	*Physcia dilitata* Nyl.	
25	*Punctelia rudecta* (Ach.) Krog	
26	*Pyxine berteriana* (Fée) Imshaug	
27	*Ramalina conduplicans* Vain.	
28	*Rinodina sophodes* (Ach.) A. Massal.	

4.1-6.0 cm also exhibits good growth of lichens with 28 and 32 species (Tables 1B, 2B). The diameter class 1.0-2.0 cm also exhibits rich diversity of lichens represented by 34 species in *Q. semecarpifolia* and 29 in *Q. leucotrichophora* (Tables 1A, 2A).

Wolseley and Pryor (1999), while studying the twig lichens on *Quercus petraea* in Welsh Woodland site (Tycanol), demonstrated that the lichen flora of twigs may vary in species, frequency and in rates of succession with local environmental conditions. A correlation

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Plate 1

1-8. Common crustose lichens growing on Oak tree twigs in different diameter classes. 1. *Lecanora achroa* Nyl. 2. *Diorygma junghuhnii* (Mont. & Bosch) Kalb & al. 3. *Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth. 4. *Graphis lineola* Ach. 5. *Lecanora alba* Lumbsch. 6. *Graphis scripta* (L.) Ach. 7. *Ochrolechia* sp. 8. *Diorygma heiroglyphicum* (Pers.) Staiger & Kalb.

Plate 1

Table 2A. Lichens growing on *Quercus semecarpifolia* bark in different diameter classes.

S.N.	1-2 cm	2.1-4.0 cm
1	*Amandinea punctata* (Hoffm.) Coppins & Scheid.	*Amandinea punctata* (Hoffm.) Coppins & Scheid.
2	*Arthothelium albescens* Patw. & Makhija	*Arthothelium albescens* Patw. & Makhija
3	*Bacidia millegrana* (Taylor) Zahlbr.	*Bacidia millegrana* (Taylor) Zahlbr.
4	*Bulbothrix setschwanensis* (Zahlbr.) Hale	*Bulbothrix setschwanensis* (Zahlbr.) Hale
5	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.	*Caloplaca bassiae (Willd. ex Ach.) Zahlbr.*
6	*Candelaria concolor* (Dicks.) Stein	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.
7	*Candelariella* sp.	*Candelaria concolor* (Dicks.) Stein
8	*Cetrelia braunsiana* (Müll. Arg.) W. Culb. & C. Culb	*Collema subconveniens* Nyl.
9	*Cetrelia cetrarioides* (Del. Ex Duby) W. Culb. & C. Culb	*Diorygma heiroglyphicum* (Pers.) Staiger & Kalb
10	*Everniastrum cirrhatum* (Fr.) Hale	*Everniastrum cirrhatum* (Fr.) Hale
11	*Graphis lineola* Ach.	*Flavoparmelia caperata* (L.) Hale
12	*Graphis proserpens* Vain.	*Graphis lineola* Ach.
13	*Graphis subserpentina* Nyl.	*Graphis proserpens* Vain.
14	*Heterodermia diademata* (Taylor) D.D. Awasthi	*Heterodermia diademata* (Taylor) D.D. Awasthi
15	*Heterodermia incana* (Stirt.) D.D. Awasthi	*Heterodermia firmula* (Nyl.) Trevis.
16	*Lecanora achroa* Nyl.	*Heterodermia incana* (Stirt.) D.D. Awasthi
17	*Lecanora alba* Lumbsch	*Lecanora achroa* Nyl.
18	*Lecidella* sp.	*Lecanora alba* Lumbsch
19	*Myelochroa subaurulenta* (Nyl.) Elix & Hale	*Myelochroa subaurulenta* (Nyl.) Elix & Hale
20	*Parmotrema austrosinense* (Zahlbr.) Hale	*Parmelaria thomsonii* (Stirt.) D.D. Awasthi
21	*Parmotrema nilgherrense* (Nyl.) Hale	*Parmotrema nilgherrense* (Nyl.) Hale
22	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.	*Parmotrema reticulatum* (Taylor) M. Choisy
23	*Phaeophyscia hispidula* (Ach.) Moberg	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.
24	*Phaeophyscia endococcina* (Körb.) Moberg	*Phaeophyscia hispidula* (Ach.) Moberg
25	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi	*Phaeophyscia endococcina* (Körb.) Moberg
26	*Physcia dilitata* Nyl.	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi
27	*Punctelia rudecta* (Ach.) Krog	*Physcia dilitata* Nyl.
28	*Pyxine berteriana* (Fée) Imshaug	*Punctelia rudecta* (Ach.) Krog
29	*Ramalina sinensis* Jatta	*Pyxine berteriana* (Fée) Imshaug
30	*Ramalina conduplicans* Vain.	*Rinodina sophodes* (Ach.) A. Massal.
31	*Rinodina sophodes* (Ach.) A. Massal.	*Ramalina sinensis* Jatta
32	*Usnea eumitrioides* Motyka	*Usnea eumitrioides* Motyka
33	*Usnea sinensis* Mot.	
34	*Usnea subfloridana* Stirt.	

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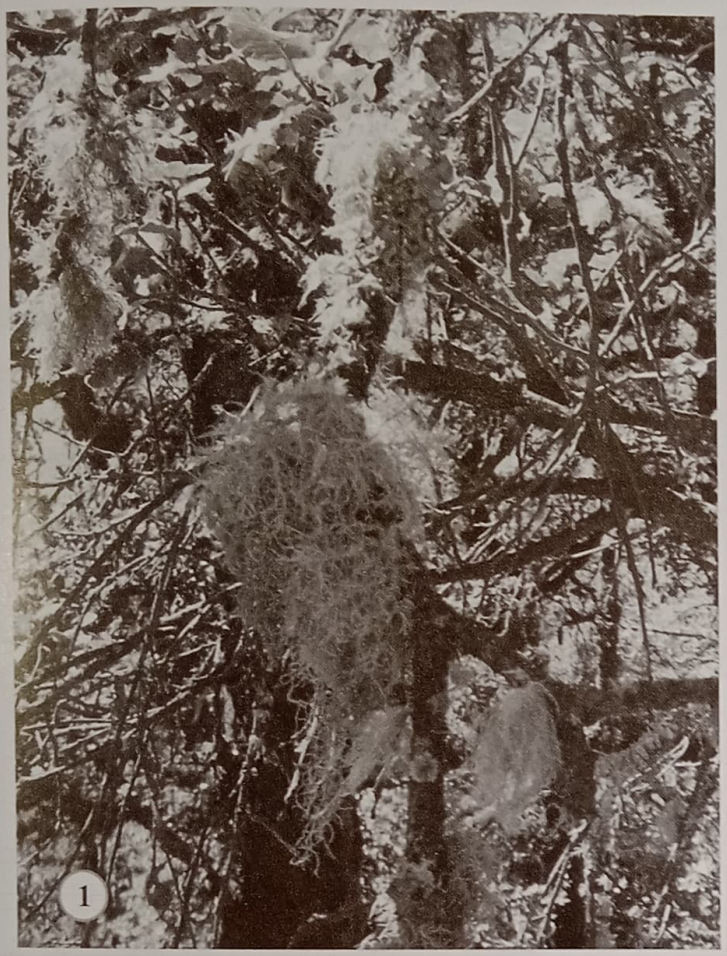
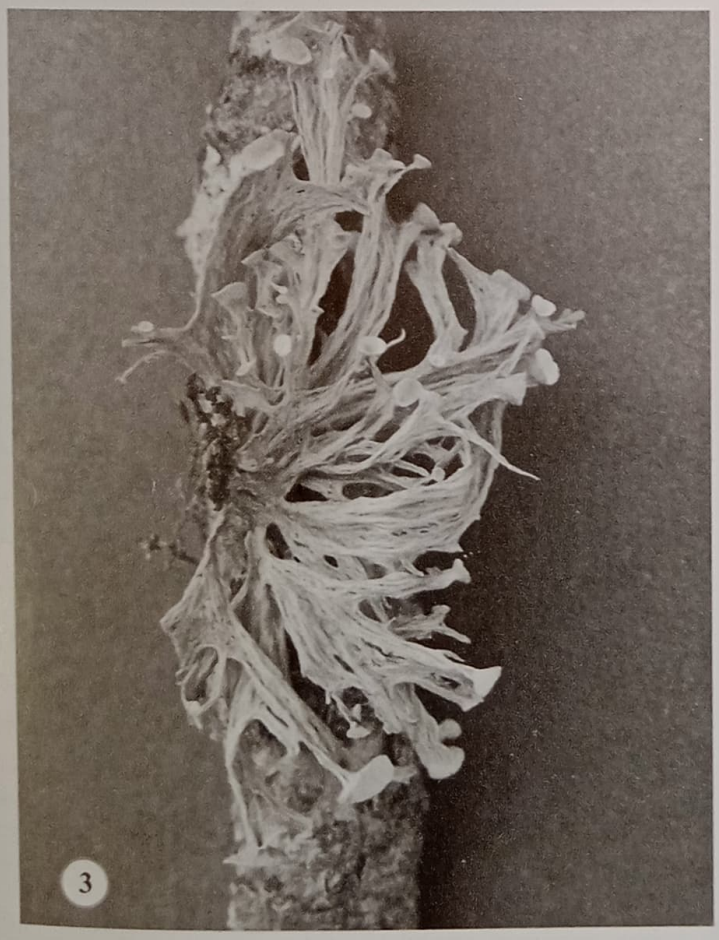
Plate 2

1-4. Common fruticose lichens growing on Oak tree twigs in different diameter classes. 1. *Usnea eumitrioides* Motyka. 2. *Usnea subfloridana* Stirt. 3. *Ramalina sinensis* Jatta. 4. *Ramalina conduplicans* Vain.





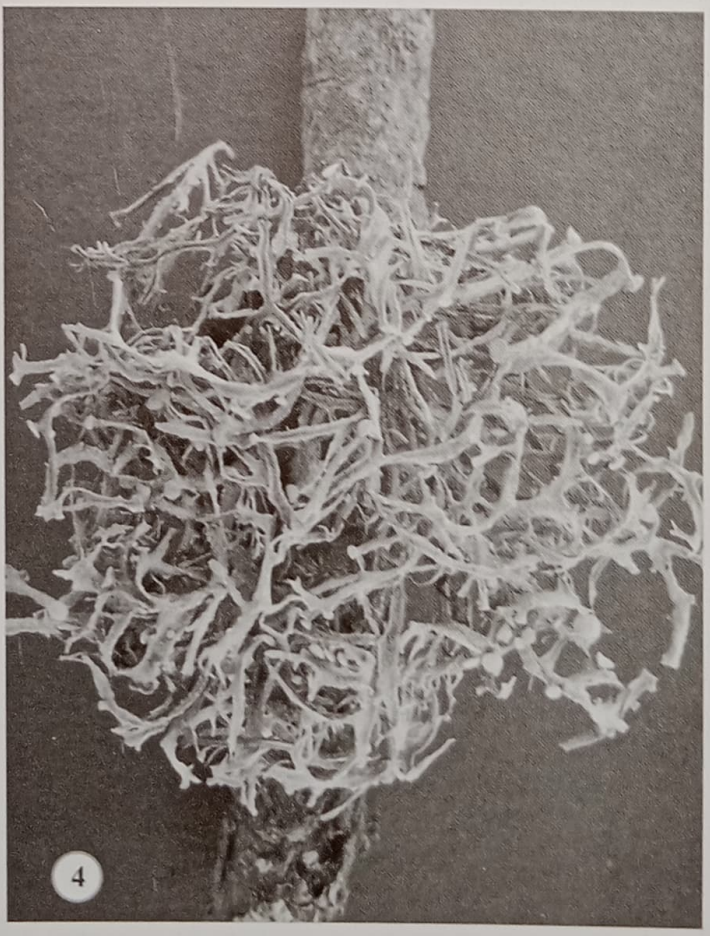


Plate 2

Table 2B. Lichens growing on *Quercus semecarpifolia* bark in different diameter classes.

S.N.	4.1-6.0 cm	6.1-8.0 cm
1	*Amandinea punctata* (Hoffm.) Coppins & Scheid.	*Bulbothrix setschwanensis* (Zahlbr.) Hale
2	*Bacidia millegrana* (Taylor) Zahlbr.	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.
3	*Bulbothrix setschwanensis* (Zahlbr.) Hale	*Everniastrum cirrhatum* (Fr.) Hale
4	*Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth.	*Heterodermia diademata* (Taylor) D.D. Awasthi
5	*Candelaria concolor* (Dicks.) Stein	*Heterodermia firmula* (Nyl.) Trevis.
6	*Collema leptaleum* Tuck.	*Lecanora achroa* Nyl.
7	*Diorygma heiroglyphicum* (Pers.) Staiger & Kalb	*Lecanora alba* Lumbsch
8	*Everniastrum cirrhatum* (Fr.) Hale	*Myelochroa subaurulenta* (Nyl.) Elix & Hale
9	*Graphis lineola* Ach.	*Ochrolechia* sp.
10	*Graphis proserpens* Vain.	*Parmotrema nilgherrense* (Nyl.) Hale
11	*Heterodermia diademata* (Taylor) D.D. Awasthi	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.
12	*Heterodermia firmula* (Nyl.) Trevis.	*Phaeophyscia hispidula* (Ach.) Moberg
13	*Heterodermia incana* (Stirt.) D.D. Awasthi	*Phaeophyscia endococcina* (Körb.) Moberg
14	*Lecanora achroa* Nyl.	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi
15	*Lecanora alba* Lumbsch	*Physcia dilitata* Nyl.
16	*Myelochroa subaurulenta* (Nyl.) Elix & Hale	*Punctelia rudecta* (Ach.) Krog
17	*Parmelaria thomsonii* (Stirt.) D.D. Awasthi	*Rinodina sophodes* (Ach.) A. Massal.
18	*Parmotrema austrosinense* (Zahlbr.) Hale	
19	*Parmotrema nilgherrense* (Nyl.) Hale	
20	*Parmotrema reticulatum* (Taylor) M. Choisy	
21	*Pertusaria himalayensis* D.D. Awasthi & P. Srivast.	
22	*Pertusaria leucosorodes* Nyl.	
23	*Pertusaria quassiae* (Fée) Nyl.	
24	*Phaeophyscia hispidula* (Ach.) Moberg	
25	*Phaeophyscia endococcina* (Körb.) Moberg	
26	*Phaeophyscia pyrrhophora* (Poelt) D.D. Awasthi & M. Joshi	
27	*Physcia dilitata* Nyl.	
28	*Punctelia rudecta* (Ach.) Krog	
29	*Pyxine berteriana* (Fée) Imshaug	
30	*Ramalina conduplicans* Vain.	
31	*Rinodina sophodes* (Ach.) A. Massal.	
32	*Usnea subfloridana* Stirt.	

between environmental condition and lichen communities of twigs and their indicator species can be used to detect trends of acidification or eutropication.

Similarly, in the present study different diameter classes of twigs of the *Q. semecarpifolia* and *Q. leucotrichophora* exhibit different bark pH values as

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Plate 3

1-5. Common foliose lichens growing on oak tree twigs in different diameter classes. 1. *Bulbothrix meizospora* (Nyl.) Hale. 2. *Physcia dilatata* Nyl. 3. *Heterodermia diademata* (Taylor) D. D. Awasthi. 4. *Candelaria indica* (Hue) Vain. 5. *Parmotrema nilgherrense* (Nyl.) Hale. 6. *Everniastrum cirrhatum* (Fr.) Hale

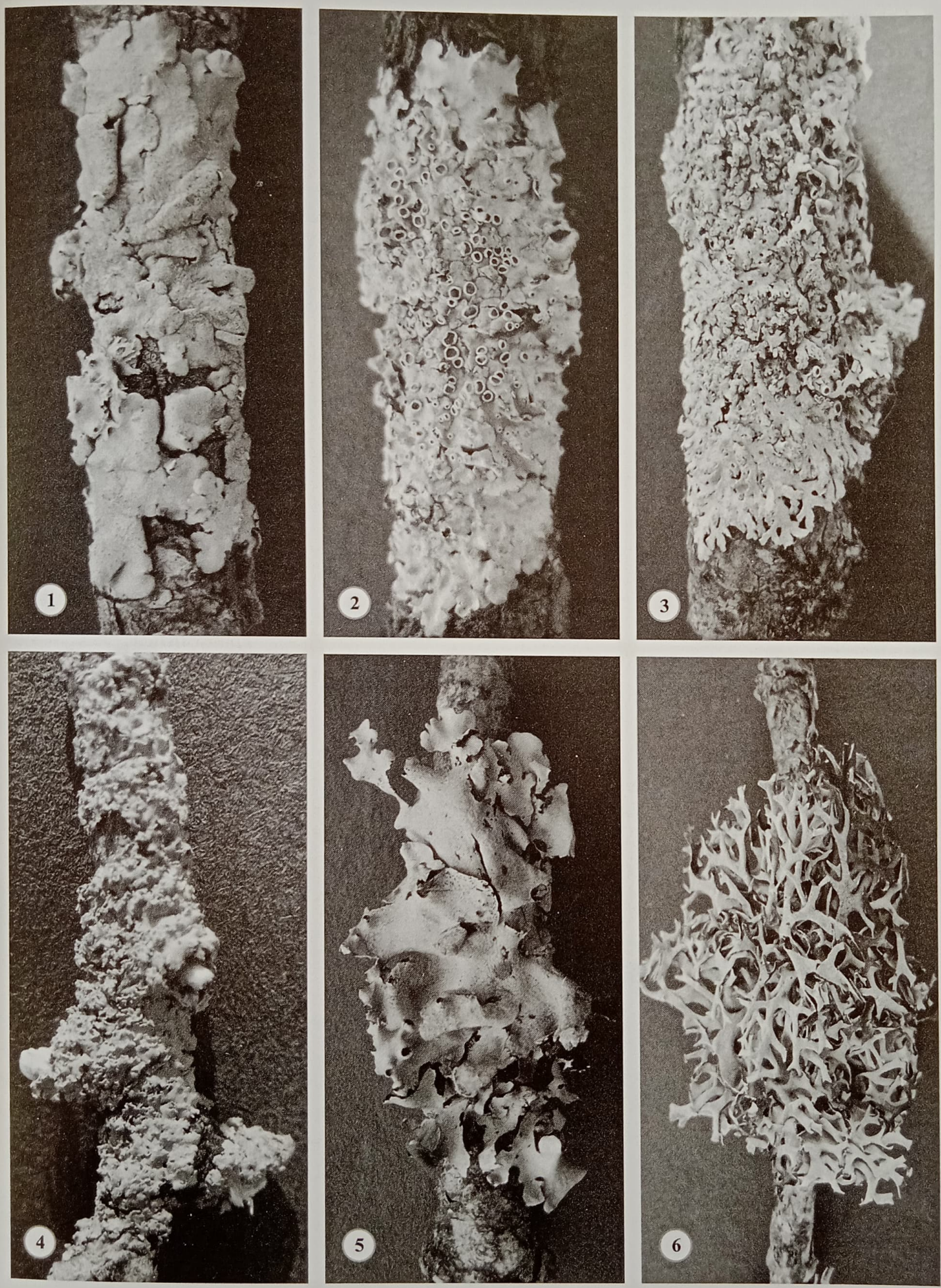


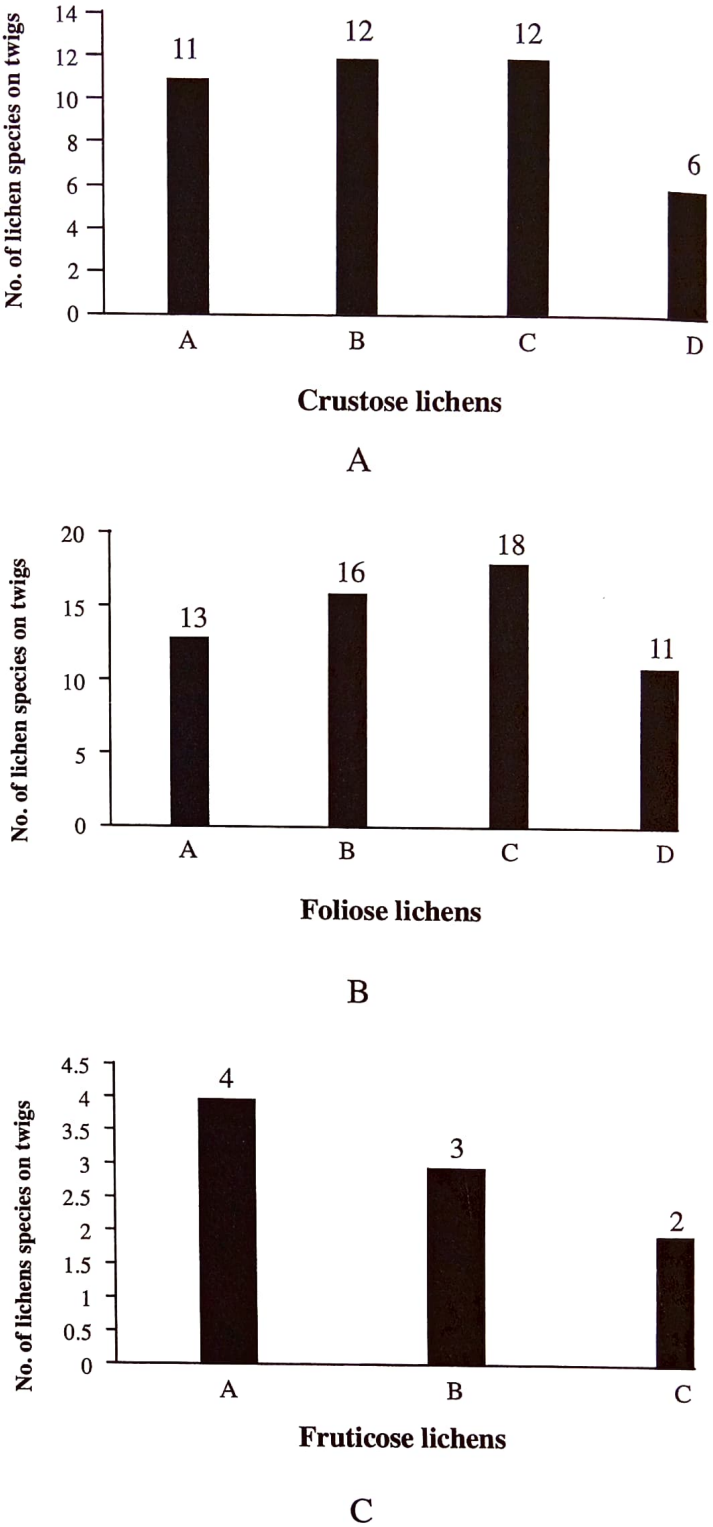
Plate 3

Table 3: pH of different classes of twigs from Nainital district. Uttarakhand

Localities	Diameter in cm	pH value
Snow View	1.0-2.0	8
	2.1-4.1	7.5
	4.1-6.0	6.5
Birla Chungi	2.1-4.1	6.5
	4.1-6.0	7
	6.1-8.0	7.5
Thirty-six Sheeri	2.1-4.1	6.5
	4.1-6.0	7
Naina Peak	1.0-2.0	8
	2.1-4.1	7.5
	6.1-8.0	6.5
Kumaun Lodge	2.1-4.1	6.5
	6.1-8.0	7
Ayar Patta	1.0-2.0	7
	2.1-4.1	6.5
	4.1-6.0	6
Tiffin Top	1.0-2.0	6.5
	2.1-4.1	6.5
	4.1-6.0	7
Tower Compound	1.0-2.0	6
	2.1-4.1	8
	4.1-6.0	7

the diameter of the twigs increases therefore the twigs may vary in types of lichen taxa. The diversity of twig lichens exhibits a decreasing trend as the diameter of twigs increase in both the trees. The acidity also increases as the diameter classes of the twigs increase in diameter and only some foliose and fruticose species increase in their size and replace most of the pioneers (Text-figures 1-2).

The twigs of *Q. leucotrichophora* in Plains View and on way to Tara Hall localities represented the occurrence of 4 and 6 species of lichens respectively. The probable reason for poor lichens on twigs may be attributed to the proximity of both the localities to the city centre with high anthropogenic activities. The localities have scattered trees with open canopy which allow more light and low moisture thus allows only a few lichens to grow.

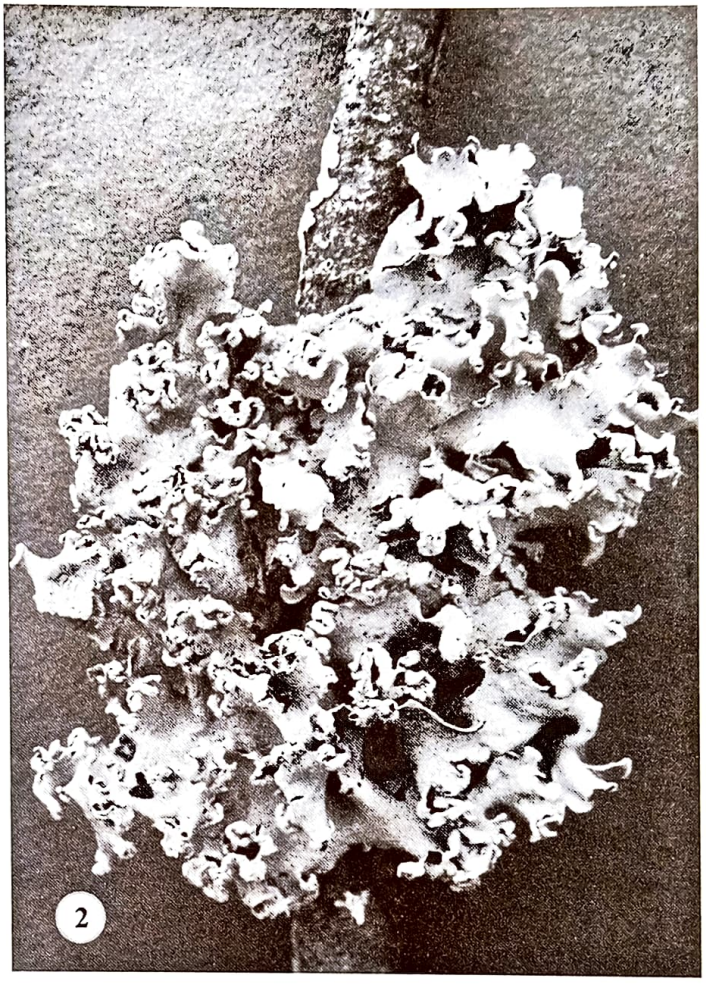


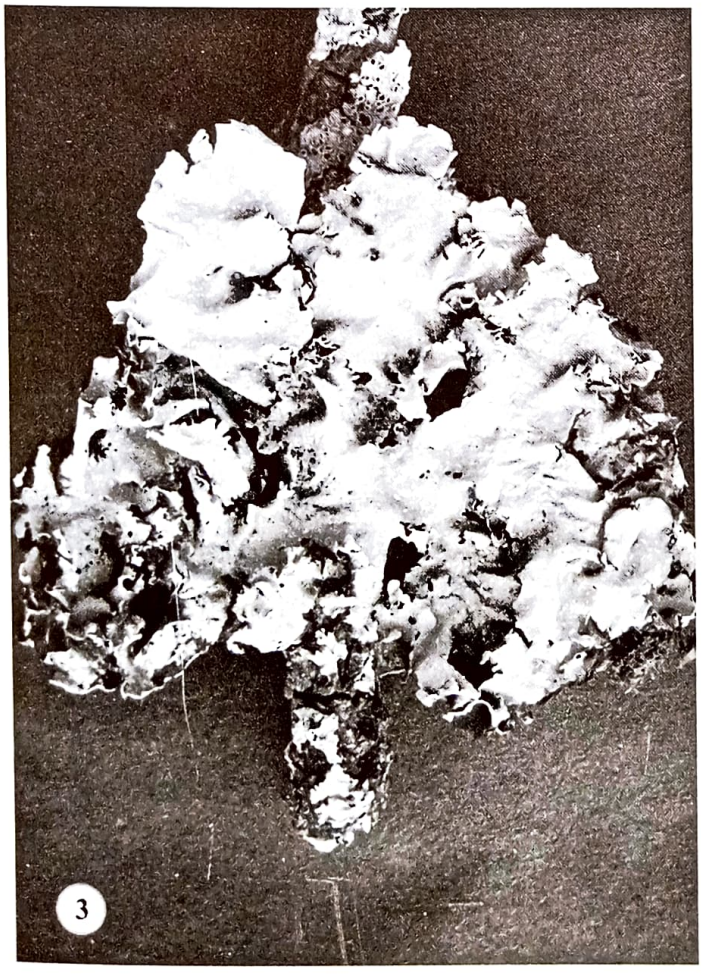
Text-figure 1. Lichen growth forms on *Quercus leucotrichophora* twigs in different diameter classes. A= 1-2 cm; B= 2.1-4.0 cm; C=4.1-6.0 cm; D= 6.1-8 cm diameter.

→

Plate 4

1-4. Common foliose lichens growing on oak tree twigs in different diameter classes. 1. *Cetrelia braunsiana* (Müll. Arg.) W. Culb. & C. Culb. 2. *Parmotrema austrosinense* (Zahlbr.) Hale. 3. *Punctelia rudecta* (Ach.) Krog. 4. *Parmotrema reticulatum* (Taylor) M. Choisy





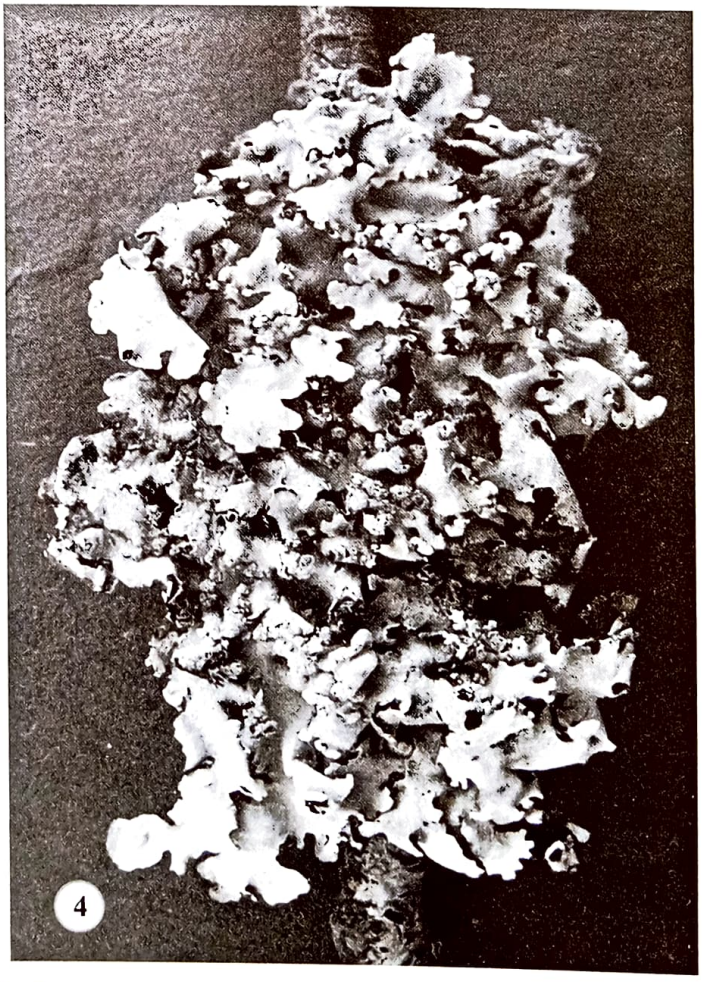
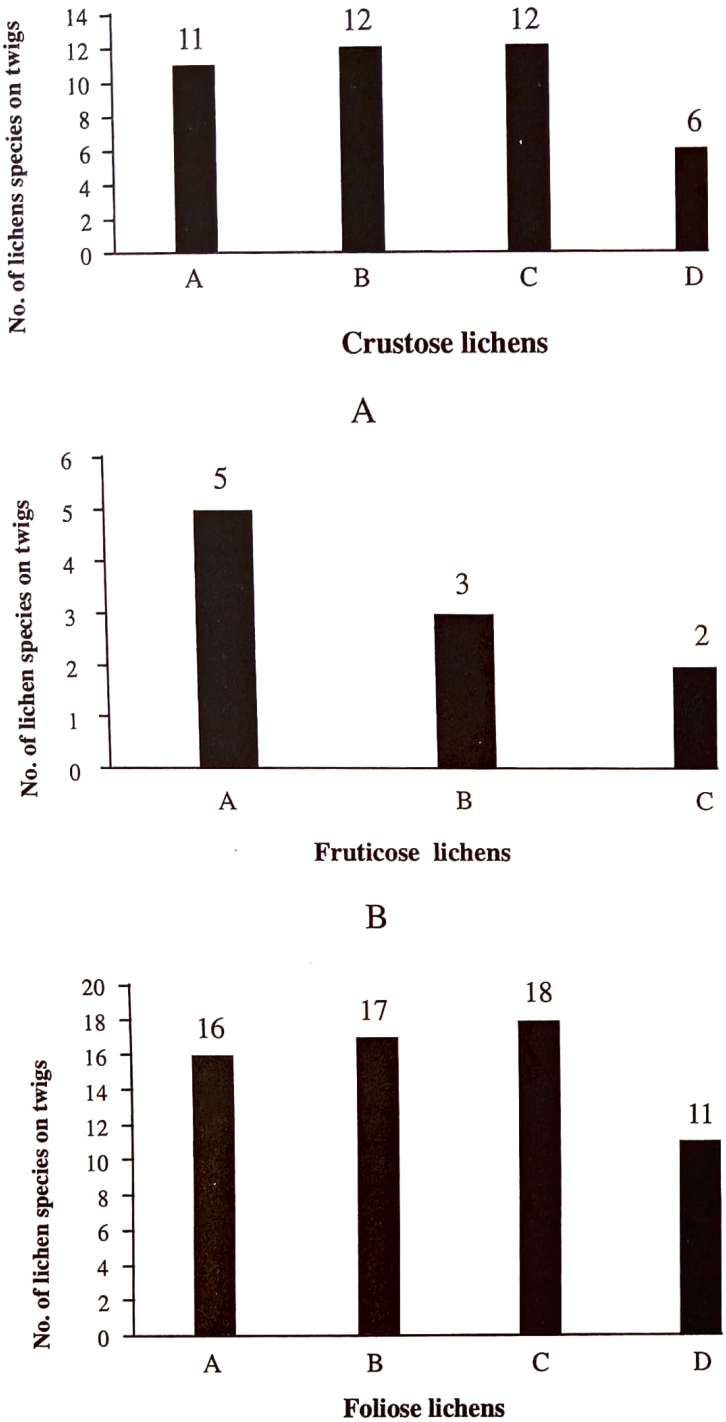


Plate 4



Text-figure 2. Lichens growth forms on *Quercus semecarpifolia* twigs in different diameter classes. A= 1-2 cm; B= 2.1-4.0 cm; C=4.1-6.0 cm; D= 6.1-8 cm diameter.

Quercus leucotrichophora twigs collected from Ramji Hospital area (2000 m) bear maximum (32) species of twig lichens followed by D.S.B. Campus (2000 m) and Thirty Six Sheeri area (2130 m) with 28 and 27 species respectively. The *Q. semecarpifolia* twigs from Snow View area (2500 m) show maximum diversity of twig lichens represented by 31 species followed by Tower Compound (2100 m) with 29 and Tiffin Top (2292 m) with 28 species respectively.

The young twigs of diameter class 1.0-2.0 cm have dominance of crustose and foliose lichens on both the trees. The twigs further provide space to colonize more lichen taxa of both foliose and crustose forms when the twigs attain a diameter of 6 cm. After attaining a diameter of more than 6 cm the twigs exhibit reduction in the number of all the three growth forms due to increased size of the thalli of foliose and fruticose forms.

According to Stone (1989), the epiphytic lichens exhibit different type of patterns of colonization on branches. Some species are colonized on very young twigs in large numbers. Others entered the community slowly, adding individuals as sections, rarely reaching 100% frequency by the time branch sections were 20 years old. Similarly in the present study the young twigs of diameter classes 1.0-2.0, 2.1-4.0, 4.1-6.0 cm exhibit dominance of crustose and foliose together with fruticose forms (Plates 1-4). After attaining diameter of 6.1-8.0 cm, both crustose and foliose forms exhibit reduction in number while few macrolichens dominate the twigs (Text-figures 1-2). The crustose species such as *Graphis proserpens* Vain., *Amendina punctata* (Hoffm.) Coppins & Scheid., *Bacidia milligrana* (Taylor) Zahlbr., *Diorygma hieroglyphicum* (Pers.) Staiger & Kalb, *Pertusaria leucosorodes* Nyl., *Pertusaria quassiae* (Fée) Nyl. and foliose species, *Parmotrema austrosinesis* (Zahlbr.) Hale, *Collema leptimella* Tuck., *Heterodermia incana* (Stirt.) D. D. Awasthi together with *Usnea subfloridana* Stirt. and *Ramlina conduplicans* Vain., show their absence in the diameter class 6.1-8.0 cm.

The young smooth barked twigs (up to 4.0 cm diameter), with pH range 6.5-8, provide substrate for many crustose, foliose and fruticose lichen taxa to colonize. The bark becomes rough in mature twigs (more than 6.0 cm diameter) and have pH range of 6-7.5 which restricted the growth of many taxa of lichens and only few exclusive species are able to grow there (Table 3).

Similar to the observation of Kantvillas and Jarman (2004), the lichen flora of the twigs exhibits variability depending on whether the twigs are exposed to bright

light or less exposed to sun rays. The tree twigs in the fringes of forest and at canopy receive more sunlight and wind and have more lichens than the twigs of trees growing inside of the forest.

The distribution and diversity of lichens on different classes of twigs of both oak species and their pH levels can be used as base line record to monitor environmental changes in area overtime.

ACKNOWLEDGEMENT

The authors are thankful to the Director, National Botanical Research Institute, Lucknow for providing necessary laboratory facilities and to the Ministry of Environment and Forests, New Delhi for financial support.

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